N87-24273

STAR FORMING REGIONS OF THE SOUTHERN GALAXY

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ABSTRACT: A catalogue of southern dust cloud properties is being compiled to aid in the planning and analysis of radio spectral line surveys in the southern hemisphere. Ultimately, images of dust temperature and column density will be produced. For the interim, a list of the 60 and 100 μm fluxes has been prepared for the cores and adjacent backgrounds of 65 prominent dust clouds. Dust temperatures and column densities have been derived.

1. INTRODUCTION

Radio line surveys of southern molecular clouds have generally been based on catalogues of visible nebulae and radio continuum sources (e.g. Whiteoak 1983). Thus sites of star formation without such indicators may have been missed by such surveys. The IRAS far-infrared sky survey enables a more complete identification of molecular clouds by pinpointing the associated dense dust clouds.

Additionally, estimates of the temperature and column density within the clouds can be made by combining the data of the four IRAS spectral bands. The data for band 3 (60 μm) and band 4 (100 μm) are particularly useful for this purpose.

We have begun a project to identify and study southern molecular clouds present in the IRAS survey. Ultimately, we plan to produce images of estimated dust temperature and column density for these objects. In this paper we briefly discuss the method to be applied in the creation of the images, and present some preliminary results. The latter consist of the identification of 65 bright southern dust concentrations and estimates of temperature and column density towards their centers.

2. MATERIALS AND METHODS

2.1. Determination of Temperature and Column Density

Given a gas column density and dust temperature we can compute the flux measured by IRAS as discussed below. We have assumed that the optical depth of the dust can be computed from

$$\tau = \left(\frac{\text{column density}}{10^{21}\ \text{cm}^{-2}}\right) * \left(\frac{0.5\ \mu\text{m}}{\lambda}\right).$$

This corresponds to a standard gas to dust ratio, and an inverse wavelength dependence for dust opacity. The brightness was then calculated from brightness

$$= B_\lambda(T_{dust}) * (1-\exp(-\tau)) \ ,$$

where B_λ is the blackbody wavelength spectrum. This brightness was integrated over the bandpasses of the IRAS detectors (Beichman et al., 1985). Using a Newton Raphson iteration, we can invert the above equations to determine estimated dust temperature and gas column density from the 60 and 100 μm fluxes. We intend to produce images of estimated dust temperature and gas column density for southern molecular clouds by applying the NewtonRaphson method on a pixel by pixel basis to coadded grids of 60 and 100 um survey data. We prefer to reconstruct the images from the Calibrated Reconstructed Detector Data to using the Sky Brightness Images for a number of reasons. The data from the entire survey can be combined in the images, providing higher sensitivity and the potential for enhanced spatial resolution. Software is available which can remove scan-to scan variations, due to detector baseline effects, and field gradients due to extended background emission. The principal challenge will be to find a satisfactory algorithm for removal of background emission. We are presently using interactive image processing to evaluate the merits of various approaches, such as no background removal, removal of a background equivalent to the lowest pixel value, and subjective determination of cloud boundaries.

2.2. Selection of southern dust clouds

The 100-μm Sky Brightness Images were used initially for the identification of the southern dust concentrations. Bright discrete regions that could be effectively separated from the superimposed background emission of the galactic plane were selected for further processing with the facilities of the Infrared Processing and Analysis Center (IPAC). The positions of peak brightness were estimated using maps of the HCON1 series. For a comparison of 60-μm and 100-μm brightnesses, the different angular resolution for the two sets of data had to be taken into account. Accordingly, in our preliminary investigation, for each wavelength band we derived the average brightness for a 3 x 3 pixel grid centred on the pixel with the highest brightness. (The pixel spacing in the maps is 2 arcmin). The associated mean background levels around each object were also estimated. By means of the method discussed earlier, these results were then converted into temperatures and column densities.

3. RESULTS

Sixty-five of the brightest dust concentrations at 100 μm for declinations south of -10 degrees have been examined. However, because of its complexity the extended dense region near the galactic centre has been excluded. Virtually all the objects are centered near the bright HII regions listed in Gardner and Whiteoak (1974). In some cases the galactic background level is high and somewhat uncertain, and this uncertainty carries over to the brightness estimates. To examine the consequences for the derived parameters, temperatures and column densities have been computed both with and without background removal. In addition, the temperature and column density of the background has been computed. The results are represented in the three histograms of Figure 1. The similarity of the top two histograms shows that the determination of temperature is not significantly dependent on the background subtraction. In both cases, the source temperature (averaged over a 6x6 arcmin square) is about 40K. The other thing to be observed is that the background temperature appears to be very uniform, varying only between 20 and 30 K over the 113 deg of longitude covered by the sample.

Although individual objects without groups of dust regions often have similar temperatures, some exceptions exist. A prominent example is seen in the complex near l = 298°. 298.2-0.3 has a dust temperature of 52 K; 298.9-0.4 has a temperature of 44 K. 298.2-0.8 has a temperature of about 30 K. The associated background dust temperature is about 20 K. Figure 2 shows the image of the ratio of the 60 to 100 micron flux for the complex. In this instance, we adjusted the background to be zero for the lowest pixel value. A temperature image will be simiilar to the colour image, since the flux ratio is nearly a function of temperature alone. We have therefore selected the contour levels in the figure to correspond to colour temperatures from 20 to 60 K degrees in steps of 5 K.

4. DISCUSSION

Comparison of the histograms in Figures 1a and 1b suggests that the temperatures derived for the cores of prominent isolated dust clouds are not strongly affected by what is assumed for the

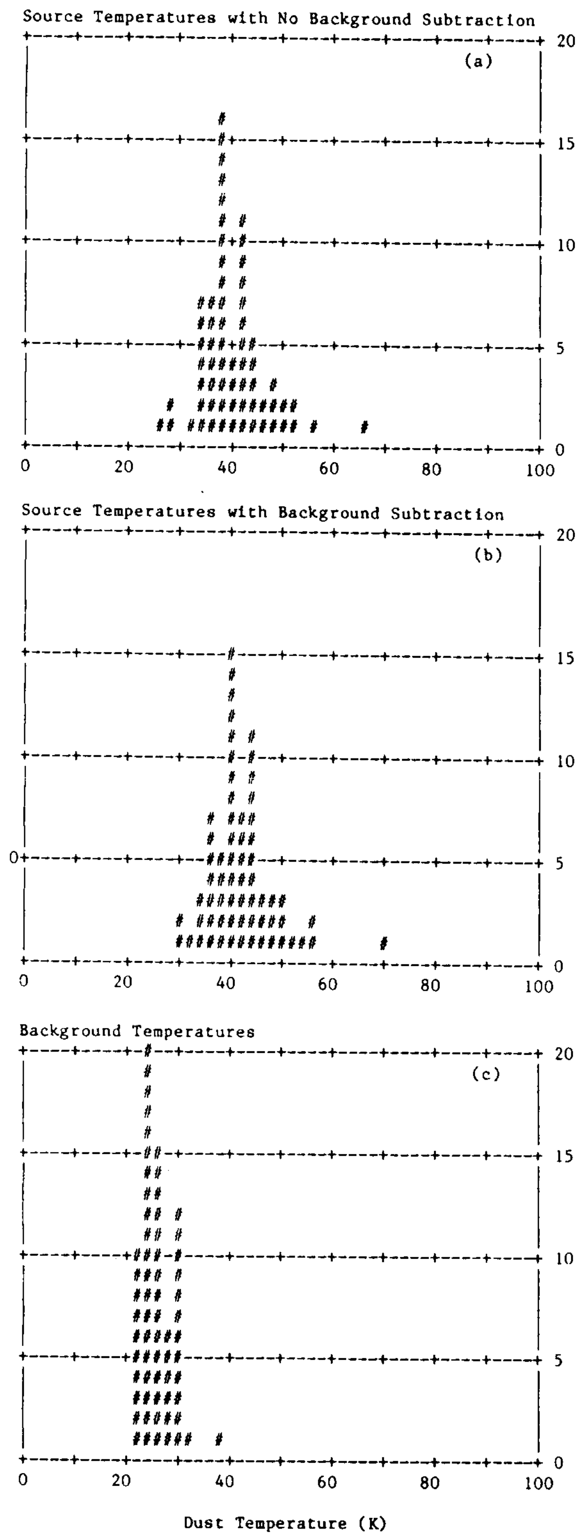

Figure 1 - Histograms of derived dust temperatures towards cores of isolated dust clouds (a) without and (b) with background emission subtract. Dust temperatures of the background emission are shown in (c).

background emission. Comparing either of those histograms with the one in Figure 1c shows that there is very little overlap; the core regions are typically 15 K warmer than the background, averaged over 9 square arcmin. Also, the background temperature is quite uniform over a large part of the Galaxy.

5. ACKNOWLEDGEMENTS

We wish to thank Gwen Manefield of CSIRO for help in compiling the cloud core data, and Walter Rice of IPAC for help in developing the image processing tasks.

The research described in this paper was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

6. REFERENCES

Beichman, C. A., Neugebauer, G., Habing, H. J., Clegg, P. E., and Chester, T. J., eds. 1985, IRAS Explanatory Supplement, (Jet Propulsion Laboratory, Pasadena), Table II.C.5.

Whiteoak, J. B. 1983, in Surveys of the Southern Galaxy, ed. Burton and Israel (Reidel), p.31.

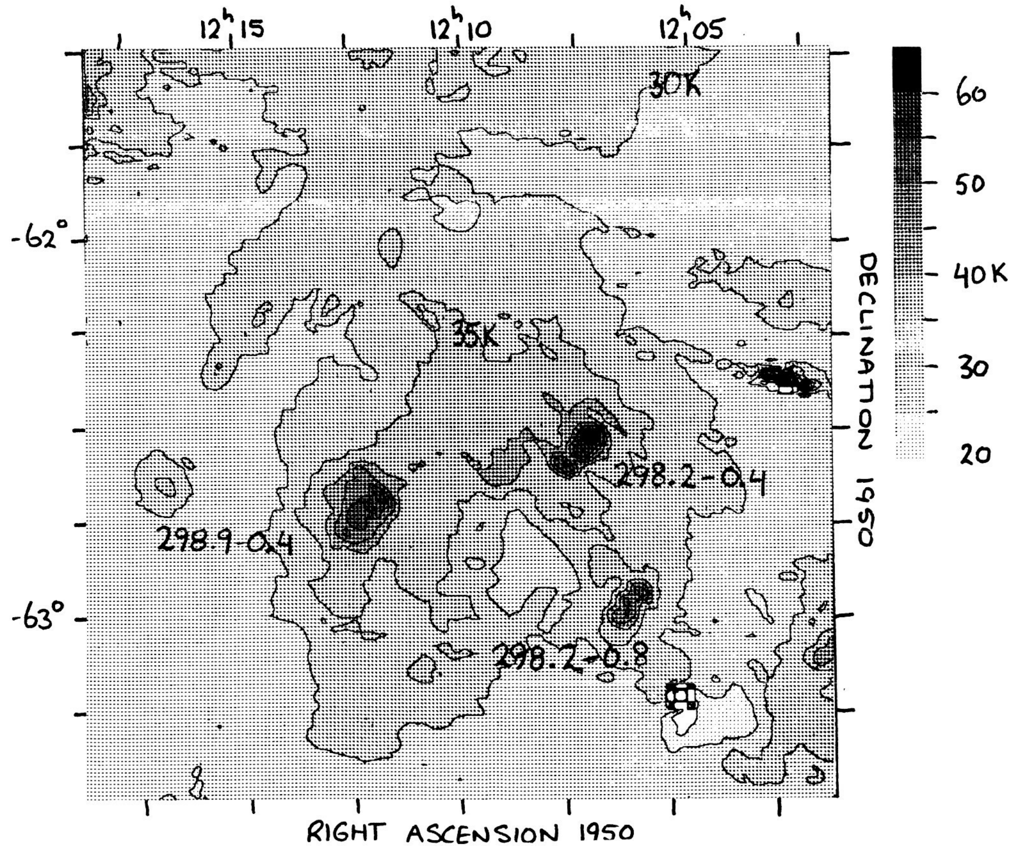

Figure 2 - Map of derived dust temperature of a 2 x 2 degree field which contains three dust condensations. The feature near the middle of the right border is an artifact.